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AN EGG GRADING
and
PROCESSING PLANT
FOR HIGH-VOLUME PRODUCTION

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AN EGG GRADING AND PROCESSING PLANT FOR HIGH-VOLUME PRODUCTION

By

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Transportation and Facilities Research Division
Agricultural Research Service

INTRODUCTION

An egg processor can no longer depend on securing a competitive advantage simply by offering products of high quality. The average quality of shell eggs produced today is high compared with that of the past, and it can be maintained by using modern techniques and equipment. Advantages are gained by performing the processing functions at lower cost. Processors today are adopting automation as a way of lowering costs.

High-volume mechanized equipment has been developed for handling eggs in both shell and liquid forms. It permits large volumes of the product to be processed in a relatively short time. However, the full potential of this equipment cannot be realized unless it is used in a plant constructed or adapted to its use. Too often, modern equipment is installed in outdated plants with the result that productivity is less than was expected. This lessened productivity is not the fault of the equipment but is caused by the limiting effects of the outdated plant.

This report describes a building and layout of equipment for an automated, high-volume plant that processes eggs in both shell and liquid form. It shows a compatible system of plant and machines that will permit the maximum production that should be expected.

Descriptions of the building and equipment are included, with an analysis of costs. This processing plant is not proposed for a specific market or location, but is intended to illustrate the principles of layout[1] and size of facility needed for the volume of product described. It is assumed that uniformly high-quality eggs would be processed, and no allowance has been made for the loss in productivity normally associated with the processing of low-quality eggs.

PLANT LAYOUT

Figure 1 shows the layout of the building and equipment for a model automated egg grading and processing plant designed for high-volume production.

Rooms are arranged to provide for short or direct flow patterns for the product and packaging materials to minimize time and labor requirements. Space requirements for some rooms are based on the dimensions of the equipment and the needed working space. The dimensions of the cooler and storage room are determined by the number and size of items to be stored, the number and size of aisles needed, the method of stacking, and the length of storage time. Equipment is arranged for economy of space and efficiency of operation.

The plant is designed to have a minimum ceiling height of 15 feet in the receiving and shipping cooler, the grading and packing room, and the packaging-materials storage room to facilitate the double-stacking of pallets of eggs and packaging materials. This ceiling height also provides needed overhead clearance for conveyors and other equipment in the grading room.

---

[1] Principles of layout and guidelines for operating egg grading and packing plants at different volume levels were developed in an earlier report: *Hamann, J. A.,* and *Todd, T. F. improved designs for commercial egg grading and packing plants.* U.S. Department of Agriculture Market. Res. Rpt. 422, 45 pp., illus. 1961.

The freezers and all other rooms in the plant except the offices have a minimum ceiling height of 10 feet. A false ceiling 8 feet in height is installed in the offices.

Plans provide for products and packaging materials being handled in the plant in palletized units, using two forklift trucks and two low-lift pallet transporters. A supply of empty pallets is stored at either end of the receiving and shipping platform, as indicated in figure 1.

Air-conditioning and heat are transmitted by ducts to the grading and packaging room and the transfer, breaking, and drawoff rooms, and to offices, lunchroom, and restrooms from central station air-handling units located in the shop and equipment room. The plant is equipped with a sprinkler system.

Plant Capacity and Operation

This plant is designed to have a washing, grading, and packaging capacity of 208 cases of shell eggs per hour, or 432,640 cases per year when operated with one shift. One shift, as used in this report, is 8 hours per day, 5 days per week, 52 weeks per year, or 2,080 hours per year. Two shifts would be double this annual figure, or 4,160 hours per year. If operated with two shifts, the plant would have a capacity for handling 865,280 cases of eggs annually.

Breaking facilities are provided primarily to process eggs from the grading operation of the plant. This operation is designed with excess capacity to take care of variations in breaking requirements that result from seasonal fluctuations in production and marketing. It is planned around the use of two breaking machines with a manufacturer's rated capacity of 18 to 24 cases per hour. Under actual operating conditions the volume handled would depend upon egg quality and the skill of the machine operators.

In the plant described, an assumption is made that production of each machine will average 18 cases per hour for a total of 65,520 cases annually using one shift, or 131,040 cases using two shifts. Presumably, the liquid eggs will be packaged and frozen in cans holding 30 pounds each or in plastic bags of various sizes.

Grading and Packing Room

In this layout, the egg grading and packing room is between the cooler and the packaging-materials storage room to reduce the distance that both eggs and packaging materials must be transported. An 8-foot aisle is provided through the center of the room for the most direct movement of these items.

Equipment in the egg grading and packing room consists of four units for washing, grading, and packing eggs. Each is rated at 60 cases per hour but under average operating conditions, 52 cases of eggs per hour can be expected.[2]

A detailed drawing of one of the four equipment units is shown in figure 2. In this drawing, the major components of each equipment unit are indicated by numbers, and work stations are indicated by letters. Five workers are needed to operate each unit, or 20 workers for the four units. Five additional workers, including a foreman, are required to support the grading and packing operation. These additional workers perform functions such as receiving, shipping, and moving the product and packaging materials within the plant.

In figure 2, a pallet load of ungraded eggs (1) and a stack of emptied pallets (2) are located at the beginning of a 2- by 20-foot gravity-roller conveyor (3) that extends to the egg washing machine (4). At the opposite end of the roller conveyor, an employee (A) using a mechanical or vacuum lift removes the eggs from cases and places them on the continuous roller conveyor of the washing machine. The eggs are thus conveyed mechanically while being washed. The washing machine consists of three sections: one for loading; one for washing, which is equipped with a detergent dispenser, water spray nozzles, and brushes; and one for drying, which is done with fans. From this machine, eggs are conveyed to the candling machine (5). The roller conveyor of the washing machine and that of the candling machine are motor-driven and timed to operate at the same speed. High-powered lights shine upward beneath the conveyor, and as the eggs pass above the lights, two candlers (B) remove undergrade eggs and place them in the undergrade tray (8).

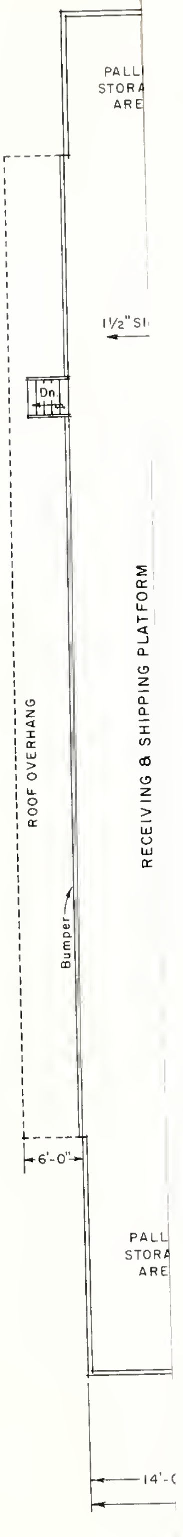
After the eggs pass the candlers, they are weighed automatically on scales (6) and move along the conveyor (7) to the automatic packing heads (9) or manual packing trays (10). Figure 3 is a photograph of the automatic packing heads. They can pack eggs small end down in either cartons or filler-flats.

Figure 2 shows five automatic packing heads. Two are used to handle large eggs, and the other three handle extra large, medium, and small sizes. This combination can be changed as the occasion demands. Jumbo and peewee eggs are packed manually from trays. A machine tender (C) performs the manual packing and tends the automatic packing heads.

Figure 2 also shows filler-flat dispensers (11) or carton dispensers (12) attached to the packing heads.

---

[2] *Forbus, W. R., Jr.* and *Hamann, J. A. evaluation of mechanized egg-grading and packing equipment.* U.S. Dept. Agr. Market. Res. Rpt. 744, 23 pp., illus. 1966.


PALL
STORA
ARE
1½" SI
Dn.
ROOF OVERHANG
RECEIVING & SHIPPING PLATFORM
Bumper
6'-0"
PALL
STORA
ARE
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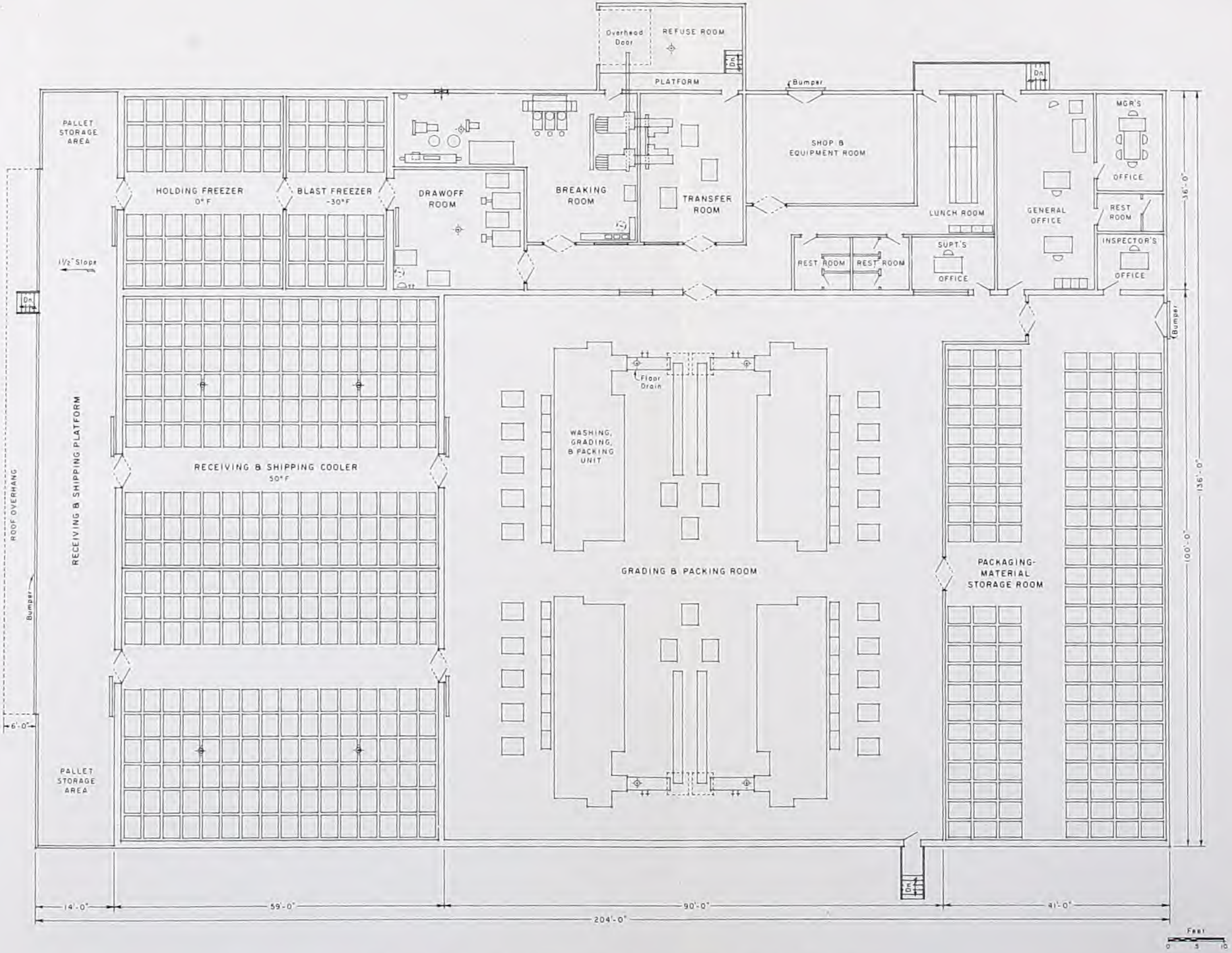

Figure 1.–Layout for an automated egg plant designed to process 208 cases of eggs per hour.

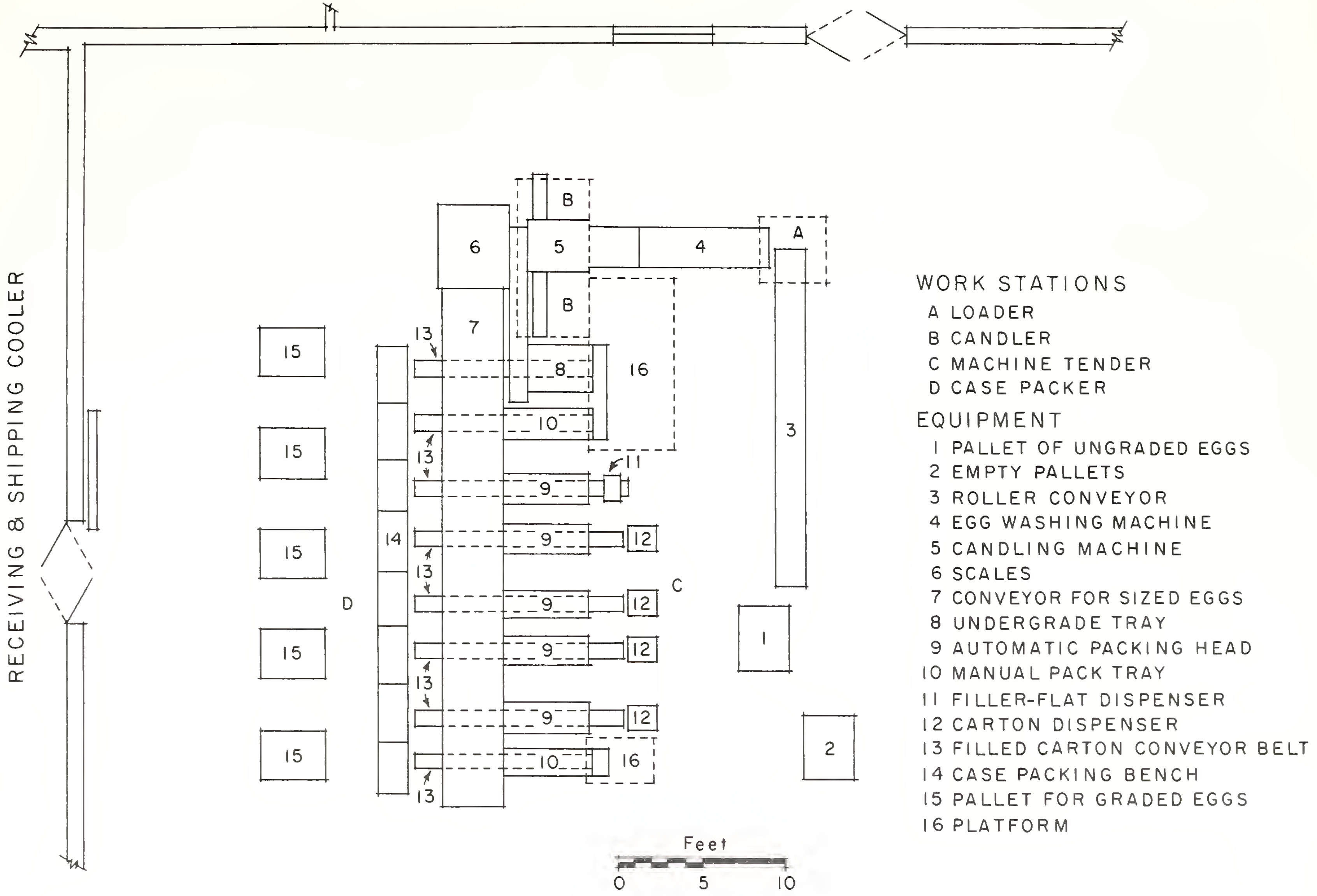

Figure 2.—Layout of one of the four units of equipment for washing, grading, and packing eggs.

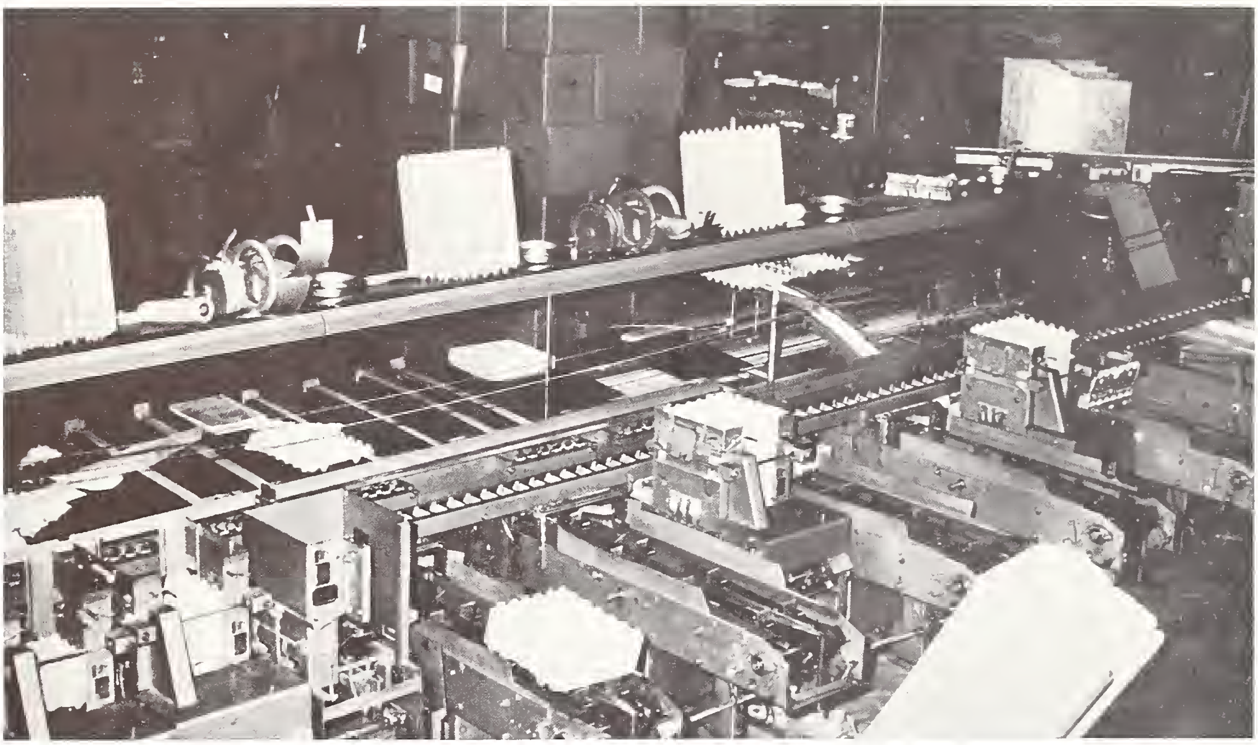

Figure 3.—After the eggs are weighed they are moved by conveyor to the automatic packing heads or to manual packing trays.

Dispensers are interchangeable between packing heads and either pulp or molded carton dispensers can be used with each packing head. Figure 4 is a photograph of filler-flat and carton dispensers.

Figure 2 shows continuous belt conveyors (13) carrying the filled cartons (or filler-flats) to a case packing bench (14). Case packer (D) places filled cartons or filler-flats in cases. Each packing bench has space for eight cases. Pallets (15) for cases of graded eggs are positioned 3 feet behind the packing bench to provide sufficient working space.

The layout (fig. 1) of the four washing, grading, and packing units is considered to be efficient. Some benefits provided by this layout are: (1) Conveyors do not obstruct movement of pallets or passage of employees; (2) ungraded eggs are held on pallets away from graded eggs (lessening congestion and the possibility of the ungraded and graded eggs becoming intermingled); and (3) sides of the equipment are accessible for cleaning and adjustment.

A floor drain 6 inches in diameter is located under each of the four washing machines, as shown in figure 1. The floor surface should slope to these drains. Outlets for hot and cold water and electricity are also provided at each of the four units. An exhaust pipe at least 8 inches in diameter extends from each washer through the roof to remove hot air and steam from the washers.

Receiving and Shipping Cooler

A single cooler for both graded and ungraded eggs is used in this plant design to use cooler space more effectively. One cooler permits flexibility in space utilization during periods when there are fluctuations in the quantity of graded and ungraded eggs on hand. However, even with the one cooler, graded and ungraded eggs are not intermingled. The cooler should be divided into two sections merely by a rigid, lightweight portable partition. One section would then be reserved for ungraded eggs and the other for graded ones. If the supply of ungraded eggs should exceed the space provided for them, the partition can be moved into the graded egg section or vice-versa.

Eggs are normally held in a cooler for varying periods before and after grading. For this reason and to keep the transport distances to a minimum, the cooler is located between the receiving and shipping platform and the grading and packing room. The cooler shares a common wall with the freezers, which affords savings in construction and operation. This design feature is further discussed in the section describing the freezers.

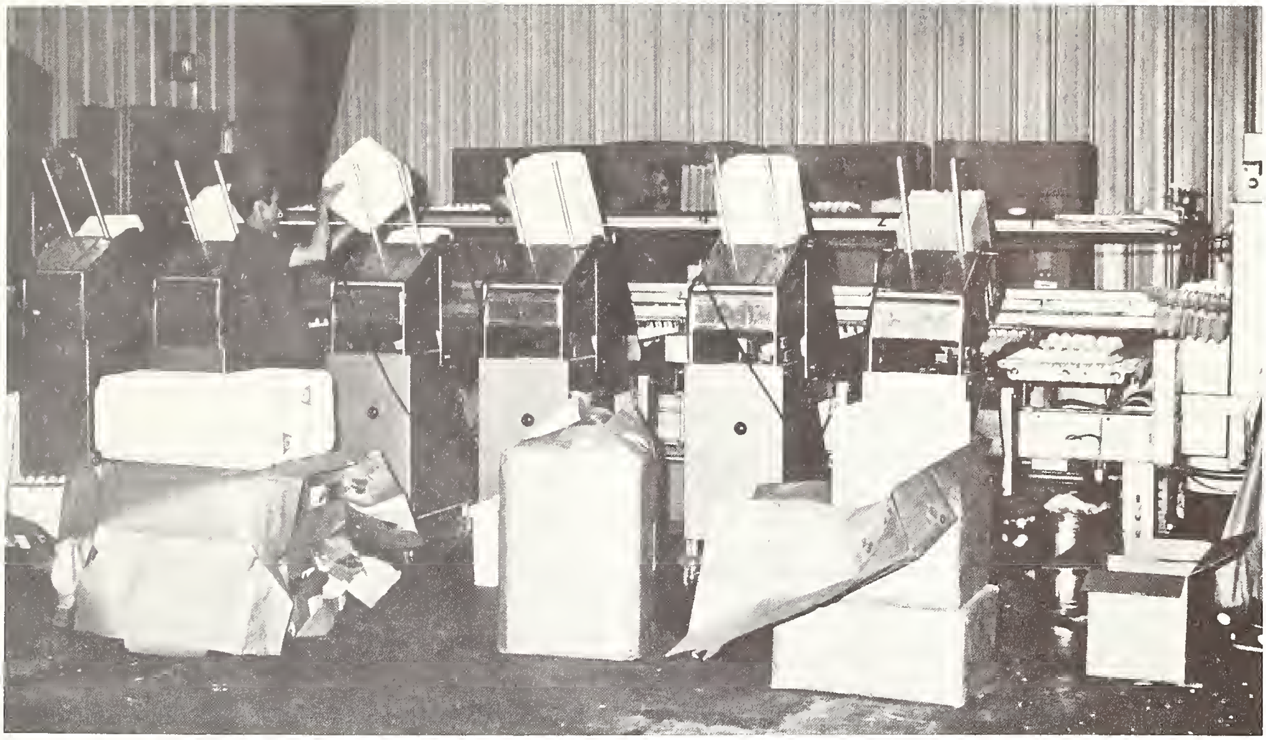

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Figure 4.—A worker loads cartons on a carton dispenser. A filler-flat dispenser is at the right.

Cases of eggs are stored on 3- by 4-foot pallets, 30 cases per pallet. When pallets of eggs are stacked two-high, the cooler will hold 576 pallet loads, or 17,280 cases. Assuming an equal quantity of ungraded and graded eggs in the cooler at one time, this amount is equal to about a 5-day supply of ungraded eggs and a 5-day accumulation of graded eggs.

At least 6 inches of space is allowed on all sides of the pallets for air circulation. With a ceiling 15 feet high in the cooler, the pallets of eggs can be double-stacked and about 4 feet of air space will still remain between the upper cases of eggs and the ceiling for air circulation. Refrigeration coils and blower equipment are suspended from the ceiling.

Hot and cold water outlets and four floor drains are provided in the cooler for cleaning purposes. Even if pallets of eggs are placed over drain openings, a drainage problem should not be created because regular washing should be done only when the stock of eggs is low. Drains are not located in the aisles because they could cause the loaded pallet transporters or forklifts to bump each time the equipment passes over them.

Two aisles, each 8 feet wide, extend through the cooler from the receiving and shipping platform to the grading and packing room. They should remain open except in emergencies when additional storage space is needed.

Receiving and Shipping Platform

A covered receiving and shipping platform is located next to the cooler. It has a roof that extends 6 feet beyond the outer edge of the platform and has walls around each end for protection during inclement weather. The platform slopes 1½ inches to the outer edge (which is 48 inches above ground level) where the trucks are parked. It is 14 feet wide to provide adequate space for pallet transporters and forklift trucks to maneuver.

One platform is used at this plant for both receiving and shipping the product to reduce construction and paving costs and to permit cross-utilization of work crews, handling equipment, and supervisory personnel.

Packaging-Material Storage Room

Bundles of cartons, filler-flats, cans, bags, cases, detergents, and other supplies will be stored in this room. Since most of the materials stored here will be used in the grading and packing operation, the storage room and the grading room are adjacent for convenience and efficiency in transporting supply materials. Aisles 8 feet wide are provided so that these materials can be moved and stacked with pallet transporters. (See fig. 5.)

Many firms buy packaging materials in large quantities because the per unit cost is usually less. A long, narrow room such as the one shown in figure 1 is desirable for large inventories because it provides many pallet facings, which are convenient for storing many different brands, sizes, and kinds of materials. This room will hold 332 palletloads of packaging materials when the pallets are double-stacked.

Breaking, Transfer, and Drawoff Rooms

The rooms used in the breaking operation (fig. 6) are alined in an order that minimizes the distance the eggs are moved during processing. The flow is orderly and progresses directly from the transfer room, to the breaking room, to the drawoff room, and then to the freezers. This operation is planned around two breaking machines, each capable of processing an average of 648 pounds of liquid eggs per hour.

Employee work stations are indicated by letters and equipment by numbers in figure 6. Five workers, including a foreman, are needed for the breaking operation. Cases of eggs to be broken are moved to the transfer room on pallets (1). Loader (A) places the cases of eggs on the benches (2) and there removes the eggs from the cases with a mechanical or vacuum lift and places them onto conveyors (3). The conveyors move the eggs from the transfer room to the breaking machines (4). Two machine operators (B) tend the egg breaking machines and inspect the egg meat. Another worker (C) carries buckets of egg meat from the breaking machines to the churns and strainers (5) where the eggs are stirred and strained. The egg meat is then pumped from the churns through pipes to a plate cooler (6) then to the bulk cooler tank (7). Next, the egg meat is pumped to the pasteurizer (8), and from there, is pumped into one of two bulk cooler tanks (9) in the drawoff room. One tank has a plastic bag filler unit (10) and the other a scale (11) where cans are filled. Filled containers are stacked on pallets (12) and then are transported to the blast freezer by a pallet transporter. Packaging materials are held on pallets (13). Empty pallets (14) are stacked nearby. The drawoff man (E) fills the plastic bags or cans with egg meat and operates the pasteurizing and pumping equipment. The foreman (D) performs miscellaneous functions and his supervisory duties.

A foot-operated lavatory (15) and a table for leaker eggs (16) are located in the breaking room. Another foot-operated lavatory is in the drawoff room. A three-compartment sink with drain rack (17) is used for

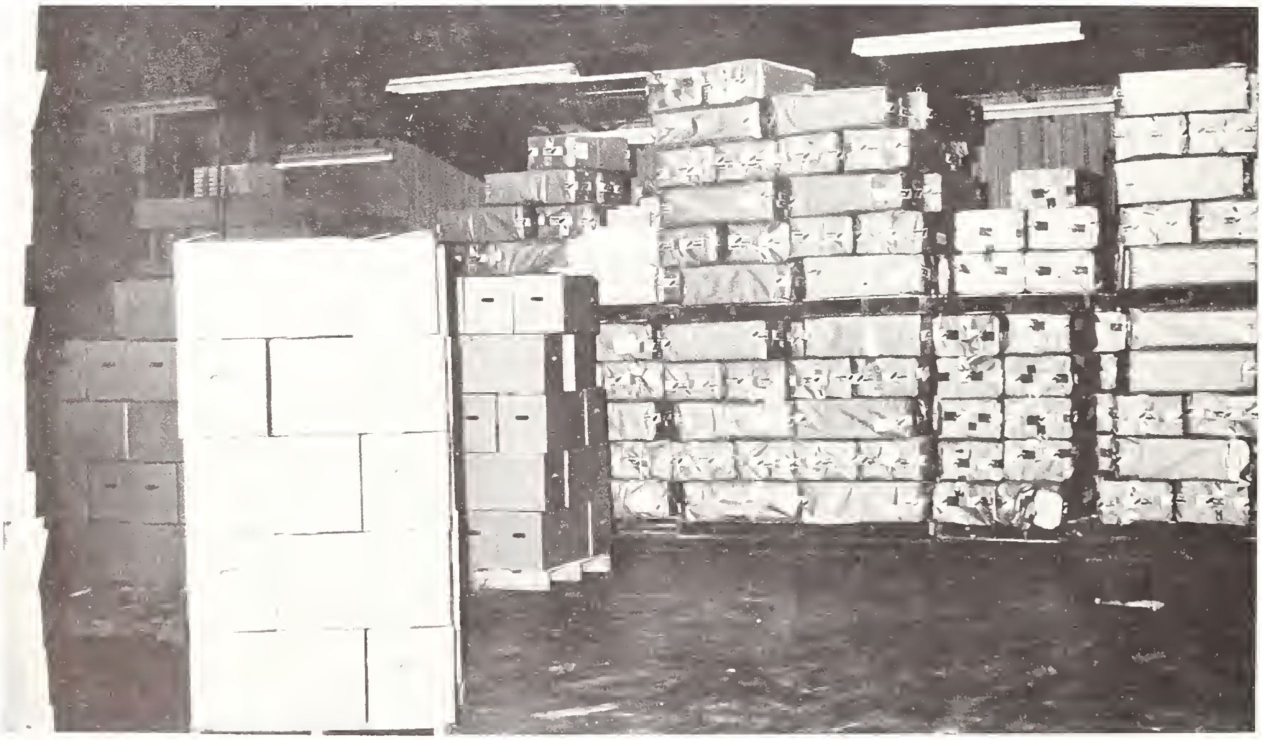

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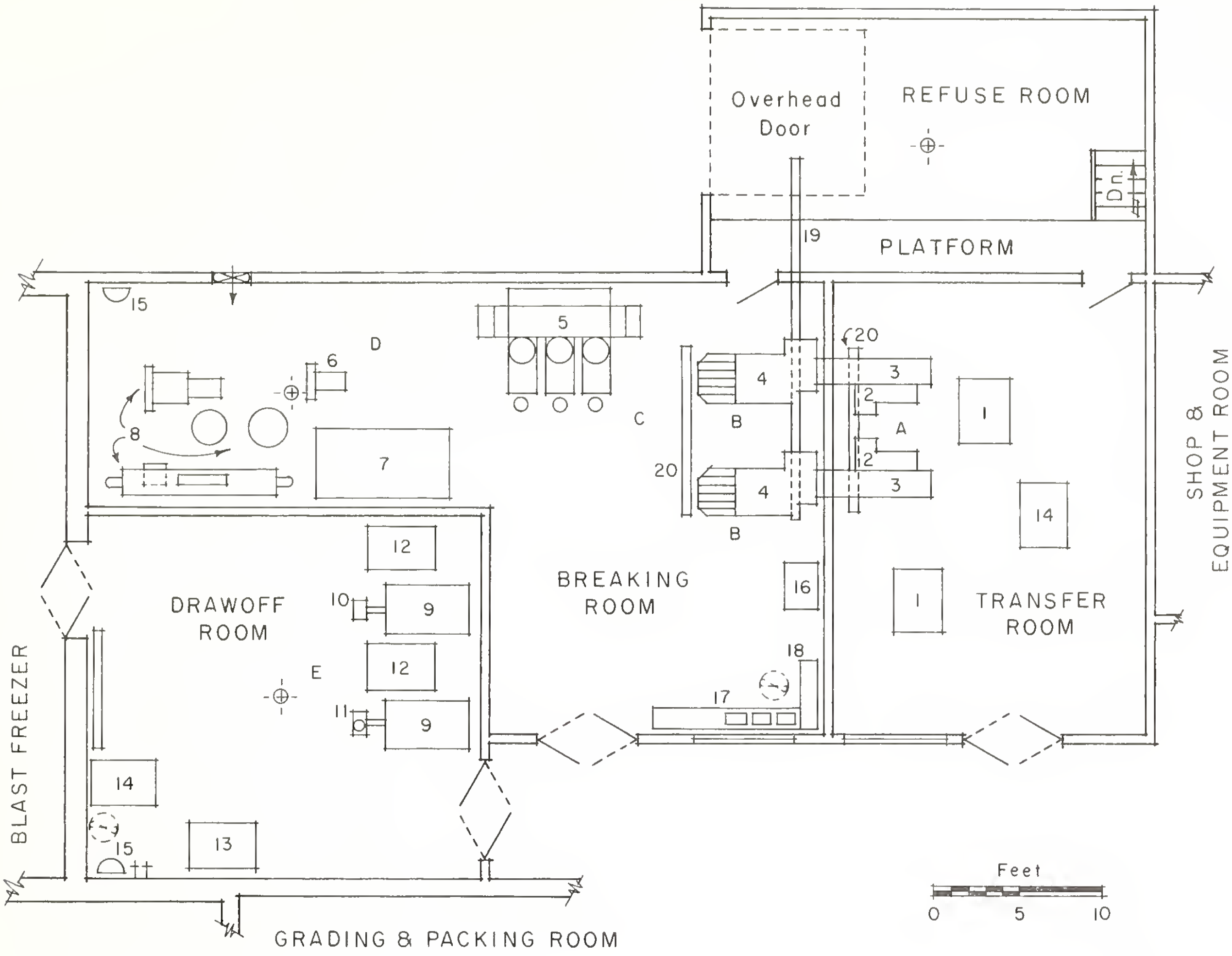
Figure 5.–Packaging materials on pallets double-stacked in storage.



WORK STATIONS

A LOADER
B MACHINE OPERATOR
C ATTENDANT
D FOREMAN
E DRAWOFF MAN

EQUIPMENT

1 PALLET OF EGGS
2 CASE BENCH
3 EGG CONVEYOR
4 EGG BREAKING MACHINE
5 CHURNS & STRAINERS
6 PLATE COOLER
7 BULK COOLER TANK (3 COMPARTMENTS)
8 PASTEURIZER & ACCESSORIES
9 BULK COOLER TANK
10 PLASTIC BAG FILLER UNIT
11 SCALE
12 PALLET OF EGG MEAT
13 PALLET OF EMPTY CONTAINERS
14 EMPTY PALLETS
15 LAVATORY (FOOT-OPERATED)
16 TABLE
17 SINK (3 COMPARTMENTS) WITH DRAIN RACK
18 RACK FOR SOILED UTENSILS
19 AUGER
20 GUTTER DRAIN
-⊕- FLOOR DRAIN
‡ HOT & COLD WATER OUTLETS
∞ FAN

Figure 6.–Layout of the transfer, breaking, and drawoff rooms.

washing, rinsing, and sterilizing utensils. It is assumed that sterilized cans would be bought and used; however, unsterilized cans could be washed, rinsed, and sanitized in the three-compartment sink. Egg shells are removed from the breaking room by an auger (18) and accumulated in the refuse room.

Floor drains in the breaking room, drawoff room, and transfer room are necessary to remove waste and water from cleanup operations. In this plan, a gutter-type drain is provided in both the transfer room and the breaking room and one 6-inch drain is provided in the breaking room and drawoff room. The number and size of these drains, located as shown in figure 6, will provide for fast and complete removal of all floor surface water. The floors and walls of these rooms are impervious to moisture and all doors to these rooms are self-closing.

The egg breaking room and the drawoff room must have a positive air pressure so that air will flow out of the room when doors are opened. No recirculated air can be used in the drawoff room unless taken from within that room. An exhaust is required in the transfer room and over the sink in the breaking room. The specific sanitation requirements for these rooms are presented in the USDA regulation governing the grading and inspection of egg products.

Freezers

The blast freezer is held at the lowest temperature of any of the refrigerated rooms. Because it is located closer to the equipment room than the other refrigerated rooms, the distance the refrigerant must be transported is relatively short. It is also located directly adjacent to the drawoff room, which minimizes the distance and time required to move the product into the blast freezer.

The blast freezer has a capacity for 32,400 pounds of egg meat packaged in 30-pound cans and stacked on 3- by 4-foot pallets with 36 cans per pallet, as illustrated in figure 7. This freezer would hold about the same quantity of egg meat packaged in plastic bags. The room temperature is maintained at –30° F.

The normal movement of frozen eggs is from the blast freezer to the holding freezer and from there to shipping. The location of the holding freezer is in this line of flow to reduce transport distance as much as possible.

The holding freezer has a capacity of 51,840 pounds of egg meat packaged in 30-pound cans and stacked 36 cans per pallet. A temperature of 0° F. is maintained in this room. Refrigeration coils and blowers are suspended from the ceiling of each freezer.

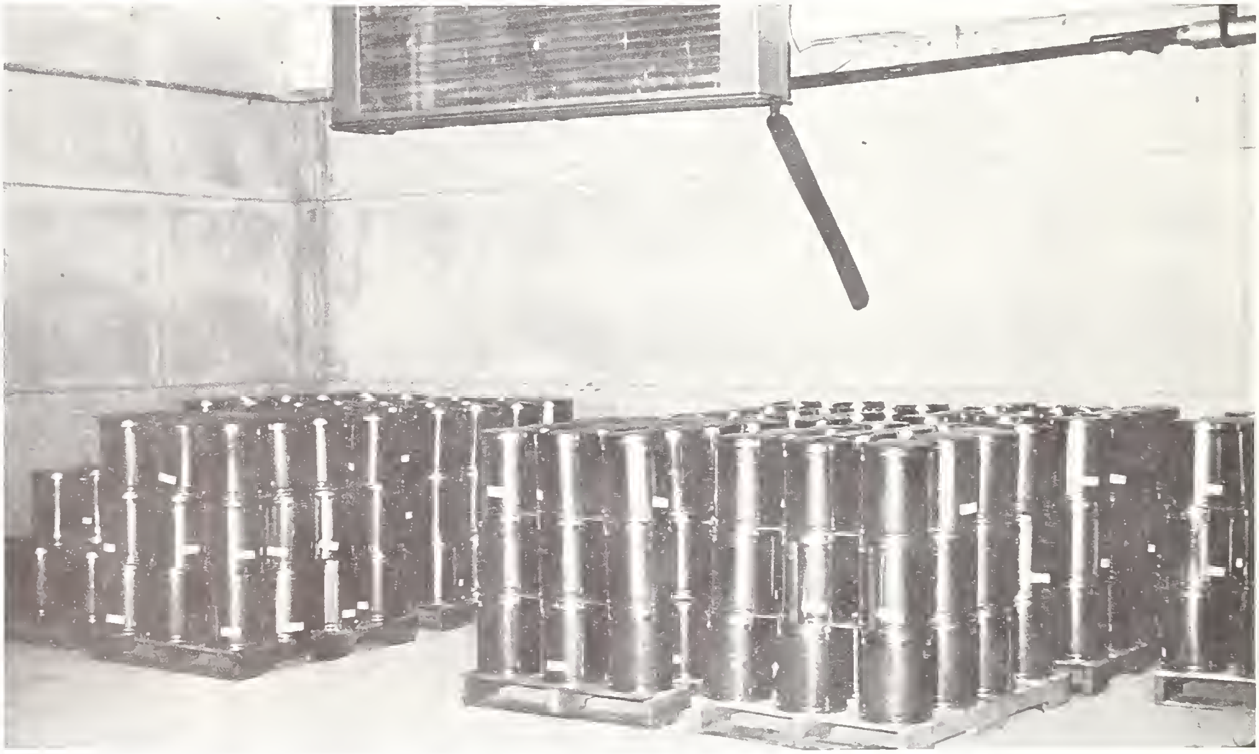


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Figure 7.–Cans of egg meat stacked 36 cans per pallet in the freezer of an egg grading and processing plant.

Both freezers are next to the receiving and shipping cooler. Some advantages of this location are (1) less heat gain occurs through common walls; (2) construction costs are lowered because less insulation is needed in common walls and less piping is needed for refrigerant; (3) all refrigerated rooms are near the refrigeration equipment room, which minimizes the distance refrigerant must be piped; (4) finished products are centrally located, which simplifies management control; and (5) all product receiving and shipping operations are centralized, which permits cross utilization of labor and equipment and reduces supervisory requirements to a minimum.

Offices, Shop and Equipment Room, Lunchroom, Refuse Room, and Hallways

The detailed office facilities and arrangement shown in figure 1 are a synthesized layout in this plan. In locating the office area, the designers have arranged for management, as the central point of control for the entire plant, to be placed in a strategic location for exercising this control. The office area has immediate access to the processing functions and it is also directly accessible to customers and producers coming to the plant. The general office serves as an entrance for visitors coming to the plant and gives management the control of these visitors necessary for preventing disruptions of processing operations.

The shop and equipment room is adjacent to an outside wall for ventilation and safety purposes. It is designed to contain the equipment necessary to produce a total of 105.3 tons of refrigeration, of which 40.2 tons are for the cooler, 17.8 tons for the two freezers, and 47.3 tons for air-conditioning. Planning also includes a boiler and plant furnace to be located in this room. The furnace should be capable of producing 341,165 B.t.u.'s per hour. The walls and ceiling of this room should be constructed so as to safeguard against fire, explosions, and leakage of water or refrigerants.[3]

The shop part of this room is necessary for maintenance and repair of plant equipment. Battery chargers for the forklifts and pallet transporters are located in this area.

The lunchroom and refuse room are not facilities used in the actual processing operations and thus do not occupy central space in the plant. This does not mean that they should be treated as afterthoughts, for each plays a necessary part in the total plant operation.

The lunchroom is for employees and should provide all the facilities necessary to employee comfort and welfare. It should be bright and clean, and should contribute to good employee morale. The refuse room provides a single collection point for the waste originating from the processing operations. Its doors should be self-closing and the room should be ventilated to the outside of the building to remove odors. Walls in the refuse room should be impervious to moisture so they can be washed frequently. Hose connections and a floor drain are provided for this reason.

The hallway provides additional separation of the grading area and the breaking area. Also, it will permit visitors to observe these operations through glass enclosures in the walls, without disrupting the operations.

BUILDING DESIGN AND COSTS

The building costs presented are based on actual costs incurred in 1966 for the construction of selected egg processing plants in the United States. They are not intended to replace firm bids for a particular job, but instead are intended to serve as an estimation of costs for this model plant.

The main building is a prefabricated, low, rigid-frame, clear-span structure. It measures 100 by 190 feet and houses the cooler, the grading and packing room, and the packaging-material storage room. The platform, freezers, drawoff room, heating and refrigeration equipment room, breaking room, transfer room, offices. lunchroom, shop, and refuse room are located in an extension to the basic building.

All outer walls of the building are steel panels. These panels have inner and outer sheets of 26-gage galvanized steel with urethane insulation formed in place between them. The outer sheet is ribbed for added rigidity.

Fiber glass insulation, 3 inches thick, with a vapor barrier is installed on the underside of the roof. This insulation forms the ceiling in all rooms except the freezers and offices. A false ceiling is installed in the offices, and additional insulation equivalent to 8 to 10 inches of cork is installed in the freezers. The outside freezer walls and the wall between the blast freezer and the refrigeration and drawoff rooms have insulation equivalent to 8 to 10 inches of cork.

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[3] Refrigeration and heating calculations are shown in the appendix.

The floor of the entire plant is concrete. It is poured over compacted soil except under the freezer, where an airspace is left between the insulation and the soil.

The building, with 27,744 square feet of floor space, is estimated to cost approximately $6.75 per square foot, or $187,272. This includes the costs of lighting and plumbing. The heating, air-conditioning, refrigeration, and sprinkler systems are estimated to cost $116,900 more. This brings the total building cost, including the items mentioned above, to $304,172, or $10.96 per square foot.

GRADING AND PACKING COSTS

Labor Cost

The production rate of 25 workers in grading and packaging 432,640 cases a year per shift, as described previously, would be 8.32 cases per man-hour. Based on a wage rate of $1.75 per hour (including fringe benefits), the labor cost for processing 100 cases of eggs would be $21.03.

Equipment Costs

The annual costs of owning and operating all the washing, grading, packaging, and materials-handling equipment[4] is $58,135 or $13.44 per 100 cases when the plant is operated with one shift. A list of the equipment needed is shown in table 1.

The annual cost of owning and operating the equipment when two shifts are used would be $69,178, or $7.99 per 100 cases. If the plant is operated with two shifts, five additional batteries would be needed—two for the pallet transporters and three for the forklifts. The additional batteries would be used while others are being recharged. Additional wooden pallets would also be required. For the purpose of this report, twice the quantity needed for one shift has been allowed. Equipment necessary for two shifts is shown in table 2.

Total Labor and Equipment Costs

The combined labor and equipment cost for processing 100 cases of eggs is $34.47 with a one-shift operation. If two shifts are used, the cost would be $29.02 per 100 cases.

BREAKING COSTS

Labor Cost

The production rate of six workers breaking 65,520 cases of eggs per year as previously described would be 5.25 cases per man-hour. At a wage rate of $1.75 per hour (including fringe benefits), the labor cost of breaking 100 cases of eggs would be $33.33.

Equipment Costs

Costs of breaking machines are based on rental charge instead of a purchase cost because most plants lease this type of equipment. Cost of all other equipment is based upon purchase prices. The equipment used is listed in table 3.

Based on an annual production time of 1,820 hours, the equipment cost for a plant operated with one shift is $11.25 per hour, or $31.25 per 100 cases of eggs. With a two-shift-per-day operation and a production time of 3,640 hours annually, the equipment cost is $10 per hour, or $27.79 per 100 cases of eggs. Table 4 shows the items of equipment for two shifts.

Total Labor and Equipment Costs

The combined annual labor and equipment cost of breaking 65,520 cases of eggs with one shift is $42,313, or $64.58 per 100 cases, and $80,095, or $61.12 per 100 cases, for breaking 131,040 cases with two shifts.

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[4] Equipment purchase prices are based on manufacturers' list prices.

TABLE 1.--Annual ownership and operating costs of washing, grading, packing, and materials-handling equipment in an egg processing plant operated with 1 shift[1]

Equipment	Number of units	Initial cost	Expected life	Ownership costs				Operating costs			Total annual equipment cost
				Depreciation	Interest[2]	Insurance and taxes[3]	Total	Power	Maintenance[4]	Total	
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
60-case-per-hour washing machine[5]	4	27,000	8.3	3,253	810	1,080	5,143	4,260	810	5,070	10,213
60-case-per-hour grading and packing machine	4	200,000	8.3	24,096	6,000	8,000	38,096	1,600	1,200	2,800	40,896
Electric pallet transporter	2	3,450	8.3	416	104	138	658	--	160	160	818
Battery: 4.15 kw.-hr.	2	700	5.0	140	21	28	189	–	–	–	189
Charger	2	900	5.0	180	27	36	243	17	–	17	260
Electric forklift truck	2	13,200	8.3	1,590	396	528	2,514	--	270	270	2,784
Battery: 14.85 kw.-hr.	[6] 3	4,020	5.0	804	121	161	1,086	–	--	--	1,086
Charger	2	2,300	8.3	277	69	92	438	151	–	151	589
Pallets (36 x 48 in.)	650	3,900	3.0	1,300	–	–	1,300	–	--	--	1,300
Total	–	255,470	–	32,056	7,548	10,063	49,667	6,028	2,440	8,468	58,135

[1] Based on 2,080 hours of operation required to process 432,640 cases of eggs a year.

[2] 6 percent of average investment (computed at 50 percent).

[3] 4 percent of initial investment.

[4] Includes preventive maintenance and downtime production loss.

[5] Manufacturers' rated capacity.

[6] Each forklift truck uses 1 battery. The additional battery is for use when either of the others are being recharged.

TABLE 2.--Annual ownership and operating costs of washing, grading, packing, and materials-handling equipment in an egg processing plant operated with two shifts[1]

Equipment	Number of units	Initial cost	Expected life	Ownership costs				Operating costs			Total annual equipment cost
				Depreciation	Interest[2]	Insurance and taxes[3]	Total	Power	Maintenance[4]	Total	
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
60-case-per-hour washing machine[5]	4	27,000	8.3	3,253	810	1,080	5,143	8,520	1,620	10,140	15,283
60-case-per-hour grading and packing machine[5]	4	200,000	8.3	24,096	6,000	8,000	38,096	3,200	2,400	5,600	43,696
Electric pallet transporter	2	3,450	8.3	416	104	138	658	–	320	320	978
Battery: 4.15 kw.-hr.	4	1,400	5.0	280	42	56	378	–	–	–	378
Charger	2	900	5.0	180	27	36	243	34	–	34	277
Electric forklift truck	2	13,200	8.3	1,590	396	528	2,514	–	540	540	3,054
Battery: 14.85 kw.-hr.	[6] 6	8,040	5.0	1,608	242	322	2,172	–	–	–	2,172
Charger	2	2,300	8.3	277	69	92	438	302	–	302	740
Pallets (36 x 48 in.)	1,300	7,800	3.0	2,600	–	–	2,600	–	–	–	2,600
Total	–	264,090	–	34,300	7,690	10,252	52,242	12,056	4,880	16,936	69,178

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[1] Based on 4,160 hours of operation required to process 865,280 cases of eggs a year.

[2] 6 percent of average investment (computed at 50 percent).

[3] 4 percent of initial investment.

[4] Includes preventive maintenance and downtime production loss.

[5] Manufacturers' rated capacity.

[6] Each forklift truck uses 1 battery. The additional battery is for use when either of the others are being recharged.

TABLE 3.--Annual breaking equipment costs for an egg processing plant operated with one shift[1]

Equipment	Number of units	Initial cost	Expected life	Ownership costs				Operating costs			Total annual equipment cost
				Depreciation	Interest	Insurance and taxes	Total	Power	Maintenance	Total	
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Breaking machines with conveyor	2	–	–	–	–	–	[2] 14,152	350	550	900	15,052
Churns with filters	3	1,845	8.3	222	55	74	351	80	50	130	481
Pasteurizer and plate cooler	1	10,000	8.3	1,205	300	400	1,905	217	283	500	2,405
Holding tanks	3	8,000	8.3	964	240	320	1,524	175	25	200	1,724
Accessory equipment[3]	–	4,055	8.3	488	101	162	751	30	30	60	811
Total	–	–	–	2,879	696	956	18,683	852	938	1,790	20,473

[1] Based on 1,820 hours of operation required to process 65,520 cases of eggs. Does not include 260 hours of cleaning time.

[2] Annual rental fee.

[3] Includes a scale, filler unit, sink, fans, pallets, and utensils.

TABLE 4.--Annual breaking equipment costs for an egg processing plant operated with two shifts[1]

Equipment	Number of units	Initial cost	Expected life	Ownership costs				Operating costs			Total annual equipment cost
				Depreciation	Interest	Insurance and taxes	Total	Power	Maintenance	Total	
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Breaking machines with conveyor	2	–	–	–	–	–	[2] 28,304	700	1,100	1,800	30,104
Churns with filters	3	1,845	8.3	222	55	74	351	160	100	260	611
Pasteurizer and plate cooler	1	10,000	8.3	1,205	300	400	1,905	434	566	1,000	2.905
Holding tanks	3	8,000	8.3	964	240	320	1,524	350	50	400	1.924
Accessory equipment[3]	–	4,055	8.3	488	101	162	751	60	60	120	871
Total	–	–	–	2,879	696	956	32,835	1,704	1,876	3,580	36,415

[1] Based on 3,640 hours of operation required to process 131,040 cases of eggs. Does not include 200 hours of clean-up time.

[2] Annual rental fee.

[3] Includes a scale, filler unit, sink, fans, pallets, and utensils.

CONCLUSION

This plant layout offers the potential for an efficient egg grading and processing operation handling a large volume of eggs.

The layout can be expanded or contracted to meet specific needs without disrupting the basic layout and process flow design. Thus, it has wide application in the egg industry.

Adoption of this plant layout can enable an egg processor to perform his processing functions at a lower cost than is common in the industry. A study[5] of 12 existing commercial egg grading and packing plants operated with one shift reported an average labor and equipment cost of $0.64 per case for washing, grading, and packing eggs. In the plant described in this report, the cost of performing these functions is estimated at $0.34 per case when the plant is operated with one shift per day and $0.29 when it is operated with two shifts per day. These costs do not include building rent, utilities, transportation, packaging materials, and administrative costs.

The breaking operation was designed primarily to handle the undergrade eggs from the grading and packaging operation. Therefore, no comparison has been made between the operational costs of breaking eggs in this plant with those of other plants. However, the same principles used to develop efficiency in the grading and packing operations were applied in designing the breaking operation.

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[5] *Jones, H. B.,* and *Thompson, J. C. marketing costs and labor productivity in commercial egg packing plants.* Univ., Ga. Bul. (n.s.) 93, 51 pp., illus. 1962. (See p. 9.)

APPENDIX

Refrigeration Requirements

Refrigeration requirements were based on an assumed outside ambient temperature of 80° to 100° F., the amount of exposure to which the eggs were subjected, and the following commodity and construction data:

Commodity Data

Temperature of incoming eggs	80° F.
Holding temperature of eggs	50° F.
Holding relative humidity	70 pct.
Latent heat in eggs from respiration	7,010 B.t.u./24 hr./ton
Latent heat in eggs from fusion (change from liquid to solid state)	100 B.t.u./lb.
Specific heat of eggs above freezing	0.76 B.t.u./lb./° F.
Specific heat of eggs below freezing	0.41 B.t.u./lb./° F.
Weight of eggs (gross)	50 lb./case

Construction data

Coefficient of transmission of temperature through cooler walls	0.10 B.t.u./hr./sq. ft./°F.
Coefficient of transmission of temperature through cooler roof	0.08 B.t.u./hr./sq. ft./°F.
Designated temperature for receiving and shipping cooler	50° F.
Designated temperature of blast freezer	−30° F.
Designated temperature of holding freezer	0° F.

Refrigeration Required for Cooler

The refrigeration requirements for the receiving and shipping cooler were calculated for 50° F. as follows:

Heat gain from transmission is $Q = AU\,t_c$

Where: Q = Outside heat transmitted into chamber (B.t.u./hr.)

A = Surface area (sq. ft.)

U = Coefficient of heat transmitted into cooler (B.t.u./hr./sq. ft./° F.)

t_c = Difference between average outside temperature and average refrigerated space temperature (° F.)

Heat gain from product load is $Q = Wc\,(t_1 - t_2)$

Where: W = Product load (lb.)

c = Specific heat of product above freezing (B.t.u./lb./° F.)

t_1 = Temperature of incoming product (° F.)

t_2 = Final storage temperature above freezing(° F.)

Heat gain from–		*B.t.u./hr.*
Transmission through cooler walls:	(944) (0.1) (35)	3,304
	(3,200) (0.1) (30)	9,600
	(400) (0.1) (30)	1,200
Transmission through cooler roof:	(5,900) (.08) (50)	23,600
Infiltration of air		2,775
Employees inside cooler		1,440
Product load:		
Initial cooling	(5,490) (50) (.76) (30)/24	260,775
Respiration	$\frac{(15{,}000)(50)(7{,}010)/24}{2{,}000}$	109,531
Electrical equipment and lights		33,904
Total heat gain per hour		446,129
		B.t.u./24 hr.
Total heat gain per day		10,707,096
Safety factor allowance (10 percent)		1,070,709
Total safety factor allowance and heat gain per day		11,777,805

Refrigeration required is 40.2 tons

Refrigeration Required for Blast Freezer

The refrigeration requirements for the blast freezer was calculated as follows for –30° F.:

Heat gain from transmission is $Q = AU t_c$

(See *Refrigeration Required for Cooler.*)

Heat gain from product load through cooling is $Q = Wc(t_1 - t_f)$

Where: t_f = Freezing temperature of product (° F.)

Heat gain from product load through fusion (change from liquid to solid state) is $Q = Wh_{if}$

Where: h_{if} = Latent heat in eggs through fusion (B.t.u./lb.)

Heat gain from–	*B.t.u./24 hr.*
Transmission through walls, floor, and roof	634,063
Infiltration of air	21,000
Product load:	
Initial cooling	98,496
Fusion	3,240,000
Final cooling	292,248
Miscellaneous (employees inside cooler, electrical equipment and lights and so forth)	114,000
Total heat gain per day	4,399,807

Refrigeration required is 15.2 tons

Refrigeration Required for Holding Freezer

The refrigeration requirements for the holding freezer was calculated as follows for 0° F.:

Heat gain from transmission is $Q = AUt_c$

(See *Refrigeration Required for Cooler.*)

Heat gain from residual heat in product load is $Q = Wct_c$

(See *Refrigeration Required for Cooler.*)

Heat gain from–	*B.t.u./24 hr.*
Transmission through walls, floor, and roof	498,590
Infiltration of air	40,000
Residual heat in product load	212,544
Miscellaneous (negligible)	--
Total heat gain per day	751,134

Refrigeration Required is 2.6 tons.

Air-Conditioning Required for All Work Areas Except Storage Areas

The assumed outside temperature used in computing the air-conditioning requirements was 95° F. The design temperature was 80° with 50 percent relative humidity for all work areas except the egg breaking room and the drawoff room. These two rooms had a designated temperature of 75°. The total air-conditioning required for all work areas except the storage areas was calculated as follows:

Heat gain from sensible (desirable or comfortable) temperature in all work areas except storage areas is Q_s (B.t.u./hr.)

Heat gain from heat latent in plant occupants, air in building, and equipment is Q_1 (B.t.u./hr.)

Heat gain from–	*B.t.u./hr.*
Sensible heat gain:	
Walls, floor, and roof	80,895
Occupants in building	11,500
Outside air drawn into air-conditioning system	13,338
Miscellaneous (equipment, motors, lights, and so forth)	285,622
Total sensible heat gain per hour	391,355
Latent heat gain:	
Occupants in building	22,500
Air in building	11,351
Equipment (washers assumed to be hooded and vented)	142,000
Total latent heat gain per hour	175,851
Total heat gain ($Q_s + Q_1$) per hour	567,206

Air-conditioning load required is 47.3 tons.

Heating Required for Entire Plant

The assumed outside temperature used in computing the plant's heating requirements was 0° F., the assumed indoor temperature used was 70° F., and the heat losses used are shown below. The total heating required for the entire plant was calculated as follows:

Heat loss from–	*B.t.u./hr.*
Transmission through walls and roof of:	
Grading and packing room	59,790
Packaging-material storage room	56,309
Offices, lunchroom, transfer area, drawoff room, breaking room, and shop	31,052
Transmission through floor	32,950
Infiltration of air	98,507
Miscellaneous	5,696
Total heat loss per hour	284,304
Reserve capacity allowance (20 percent)	56,861
Total heat loss per hour and reserve capacity allowance	341,165

Total heating capacity required is 341,165 B.t.u./hr.

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